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FINAL REPORT

DENSITY AND SPECIES COMPOSITION OF SMALL MAMMALS AND BIRDS ON THE SNAKE RIVER BIRDS OF PREY NATURAL AREA, IDAHO

SUBMITTED BY

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SUMMARY

Censuses of the mammalian and avian prey base in the Snake River Birds of Prey Natural Area and surrounding Study Area were conducted from 1975-1978. A detailed vegetation and soils map of the area was completed in 1978. Preliminary vegetation typing revealed eight distinct native vegetation associations as well as two agricultural land use types, "old" and "new" agriculture. These ten types were used as a basis for most prey sampling.

In 1976 the density of black-tailed jackrabbits *(Lepus californicus)* was significantly lower in areas hunted by golden eagles *(Aquila chrysaetos)* than the average density over the study area as a whole. Jackrabbit densities were generally higher in big sagebrush *(Artemisia tridentata)*, big sagebrush-grass associations, shadscale *(Atriplex confertifolia)*, and medium density greasewood *(Sarcobatus vermiculatus)*. Very low densities were found in areas of open grass and winterfat *(Cerratoides lanata)*. Jackrabbit concentrations apparently shifted in 1978 when dense growth of mustard *(Sisymbrium altissimum)* occurred. This apparently caused rabbit movement out of shadscale and big sagebrush-grass into big sagebrush-winterfat associations and big sagebrush. Vegetation with a dense overstory and moderately open understory was favored by jackrabbits. Any type of agricultural disturbance effectively eliminated the area involved as jackrabbit habitat.

Cottontail rabbits *(Sylvilagus nuttalli)* were most abundant in canyon riparian, canyon talus, and canyon rim sites. They were also found intermittently in rocky areas or other permanent cover near farms or in the desert. Any new agricultural development left little suitable cottontail cover. Older farming areas, which otherwise provide potential cottontail

habitat were of limited value because of the practice of periodically burning "weeds" in irrigation ditches, fence rows, and along roadsides.

Marmots *(Marmota flaviventris)* inhabited areas similar to those of cottontails, with the added requirements of water and succulent vegetation. No marmots were found in native vegetation above the canyon. Bushy-tailed wood rats *(Neotoma cinerea)* also occurred in the same habitat as that occupied by cottontails. Desert wood rats *(Neotoma lepida)* were trapped intermittently along the canyon rim and within the riparian area. Deer mice *(Peromyscus maniculatus)* comprised the most abundant small rodent species in every vegetation type. Ord's kangaroo rats *(Dipodomys ordii)* were locally abundant in disturbed areas such as roadsides and farm edge. White-tailed antelope squirrels *(Ammospermophilus leucurus)* were primarily found on the south side of the Snake River on slopes of low density vegetation. Least chipmunks *(Eutamias minimus)* were few in number and were restricted to big sagebrush.

Areas of older agricultural practices supported significantly more pheasants *(Phasianus colchicus)* than native vegetation or areas of modern agriculture. As older farms adopt modern farming techniques, the pheasant density is reduced. Chukar partridge *(Alectoris graeca)* were found on talus slopes in the Snake River canyon and its tributaries. Flocks were mobile and difficult to census.

Passerine densities and species composition varied significantly by vegetation type. Horned larks *(Eremophila alpestris)* predominated in grass, shadscale, and winterfat. "Sparrows" were most abundant in big sagebrush and greasewood. Modern agricultural development generally decreased passerine abundance, whereas older agriculture areas harbored increased "sparrow" and "blackbird" populations.

Conversion of native range to intensive agriculture results in a loss of habitat for the major mammalian prey species. Such conversion might cause a slight increase in pheasant and marmot abundance. This increase would not be enough to offset the loss of major mammalian prey to raptor populations. Most small mammals are nocturnal or crepuscular and provide little available prey for diurnal raptors.

INTRODUCTION

As one segment of a larger and integrated investigation of the ecology of the birds of prey of the Snake River Canyon and adjacent ecosystems in southwestern Idaho, this study focused on the prey base available to the three major raptors of this system: golden eagles, prairie falcons *(Falco mexicanus)* and red-tailed hawks *(Buteo jamaicensis).* The results of earlier studies (Kochert 1972, Ogden and Hornocker 1977) indicated that certain ubiquitous lagomorph and rodent species were key dietary components for raptors in the area. These important prey species were black-tailed jackrabbits, mountain cottontails, and Townsend ground squirrels *(Spermophilus townsendi).*

While the primary emphasis of the study was directed toward the major mammalian prey species, its scope included virtually the entire spectrum of mammalian, avian, and reptilian prey species. Of particular concern were the abundance and availability of alternate prey species should a major decline in the numbers of one or more of the primary mammalian prey species occur. For example, jackrabbit numbers in the Great Basin area show "cyclic" fluctuations of approximately seven-year periodicity (Gross et al. 1974). Conceivably, mortality from the plague bacillus *(Yersinia pestis)* could occasion a major decline in ground squirrel numbers. The impact of such an outbreak might be especially serious if it coincided with a low point in the jackrabbit cycle. For these reasons it was deemed important to determine the supply, distribution, and availability of alternate prey species. Secondary prey species may also constitute major dietary components for some of the other indigenous but less common raptorial birds of the area. This may be particularly true in the case of nocturnal rodents and owls. Finally, Kochert (1972) noted possible

evidence of a dietary shift from jackrabbits to avian prey--particularly pheasants--among golden eagles nesting in close proximity to agricultural lands.

Since a major portion of the lands adjoining the Snake River are presently under cultivation and much of the remaining area is potentially suitable for crop production (subject to the availability of water for irrigation), a major objective of this study was to assess the potential impact on the prey base of the conversion of native rangelands to intensive agriculture.

The stated objectives of the study were as follows:

1. Stratify the study area into major vegetation types and land-use patterns from existing aerial photographs and other means.
2. Sub-stratify the major vegetation types into basic land-use types and sample the major prey species by acceptable statistical and censusing techniques.
3. Specifically, sample for prey species in those areas identified by radio telemetry efforts (Study III) to be intensively hunted by golden eagles, prairie falcons, and red-tailed hawks.

   Aspects of vegetation composition, cover, physiography, and any other factors will be studied to determine the importance of prey vulnerability to predation.
4. Assess and compare prey densities in the different habitat and land-use types to ascertain the possible effects of different land uses upon prey densities.
5. Ascertain seasonal and yearly changes in prey species composition and densities.
6. Calculate annual prey population densities in terms of biomass

within each stratum of the total study area and in areas intensively hunted by raptors.

As originally envisioned, the prey base study was to consist of two phases. Certain facets of the overall investigation (jackrabbit and pheasant transects; cottontail, marmot, and wood rat [*Neotoma spp.*] live-trapping; and chukar and passerine censusing) were to be continued throughout its duration. During the initial two years (1975 and 1976) of the study, however, assessment of relative densities and habitat affinities of small rodents received particular attention.

An analysis of the factors influencing prey vulnerability was to be a major undertaking in Phase II. However, poor preliminary results (i.e., inadequate sample sizes and poor, low reproductive success of ground squirrels resulting from the drought conditions that prevailed in the spring of 1977) forced early termination of these efforts. A short-term evaluation of raptor utilization of desert habitats was conducted in lieu thereof, the results of which are presented in the raptor utilization report by Karen Steenhof (Appendix A). During the final two years (1977 and 1978) of the study, emphasis was shifted from assessment of relative densities of small mammals to determining distribution and relative densities of the larger prey species and passerines.

Vegetative mapping of the study area was conducted by Anita Garcia and Jim Johansen in 1977 and Charles Denny and Mark Moritsch in 1978. The vegetative inventory report by Charles Denny and Mark Moritsch outlining methods and results is presented in Appendix B. The completed vegetation map is located in the Birds of Prey office in Boise, Idaho.

The reptilian prey base study will be reported separately. This portion of the study was conducted as sub-contract to the investigation described herein.

ACKNOWLEDGMENTS

We wish to acknowledge the following personnel who assisted in collection of the data contained herein: Dave Holm, Brad James, Kathleen Montan, Pat Olmstead, Bob Rheiner and staff, Gary Smith, Frank Storts, Martha Wakefield, Stan Voshell, and Jan Wassink. We also greatly appreciate assistance given by other project members, especially Graham Smith and Lutra.

STUDY AREA

The Snake River Birds of Prey Study Area (BPSA) lies adjacent to the Snake River from Walter's Ferry to Indian Cove, Idaho (Figure 1). Within the study area is the Birds of Prey Natural Area (BPNA). The canyon is the main feature of the Birds of Prey Natural Area and provides nesting habitat for most of the raptors. The canyon is composed of basalt lavas overlying sedimentary deposits. Cliffs up to 180 m high form the walls, with the river as much as 240 m below the rim. Above the canyon the terrain is flat or rolling with occasional lava outcroppings. Annual precipitation is approximately 20 cm at Swan Falls Dam. Permanent water is found in a few springs and streams which drain into the Snake River from side draws. Summers are hot and dry; most precipitation occurs in the winter months. Ecologically, the area is classified as belonging to the Upper Sonoran Life Zone and, more specifically, in the Northern Desert Shrub Biome (Fautin 1946).

Major vegetation types which occur as relatively discrete units are big sagebrush, winterfat, greasewood, shadscale, and cheatgrass *(Bromus tectorum)*. Other less widely distributed or subdominant species include rabbitbrush *(Chrysothamnus spp.)*, spiny hopsage *(Grayia spinosa)*, budsage *(Artemisia spinescens)*, four-winged saltbush *(Atriplex canescens)*, horsebrush *(Tetradymia spp.)*, and grasses such as Sandberg bluegrass *(Poa sandbergii)*, fescues *(Festuca spp.)*, and wheat-grasses *(Agropyron spp.)*. Adjacent to the Snake River and permanent tributaries is the narrow riparian community comprising a large variety of species. Preliminary descriptions of the vegetation and physiography are given in Sigler et al. (1972) and Meiners (1970). Wilson (1975), Sigler et al. (Ibid.), and Goodnight (1973) have described the fauna.

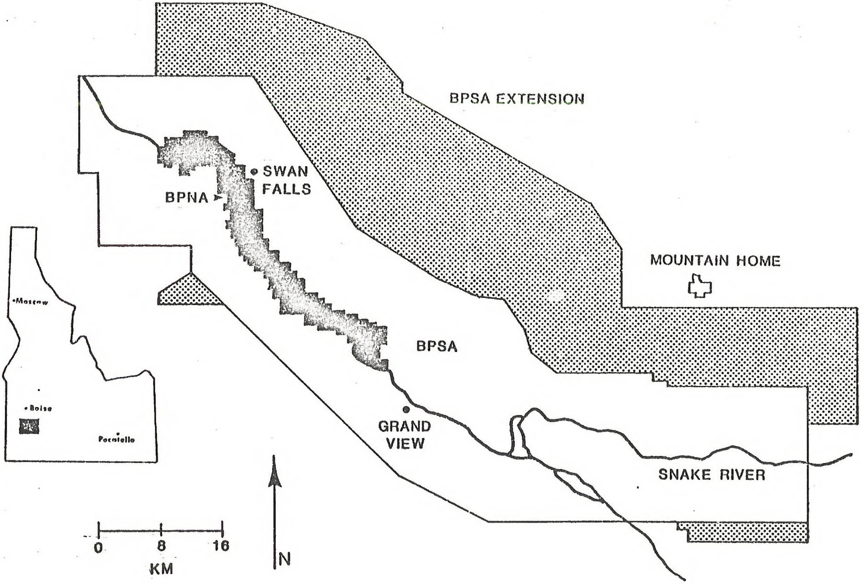

Figure 1. Location of the Snake River Birds of Prey Study Area (BPSA) showing the Natural Area (BPNA) and the 1977 expansion study area.

The two major land uses in the study area are irrigated farming and livestock grazing. Currently there is a moratorium on new agricultural developments within the study area until the research project terminates at the end of 1979. The lands within the Birds of Prety Natural Area have been withdrawn from farming, although a few farms in operation before the withdrawal are still active. Principal crops are alfalfa, potatoes, sugar beets, and small grains (Kochert 1972). Grazing by cattle and sheep is permitted within the Birds of Prey Natural Area. The Idaho National Guard uses a portion of the study area approximately 35 km^2 as a firing range and also conducts maneuvers over a larger, undetermined portion of the study area on the north side of the Snake River.

METHODS

Vegetation

A detailed vegetation map of the study area was not completed until 1978. In addition, it was not possible to census the entire spectrum of vegetation types defined by such a survey for prey species. Consequently, it was necessary to establish a preliminary stratification of vegetation types that were deemed significantly different in species composition, vegetation structure, and land-use activities to merit sampling. Montan (1976, Appendix) prepared an initial vegetation and land-use map of original Birds of Prey Study Area. The approximate boundaries and extent (i.e., percent coverage) of the major vegetation associations were obtained from color infrared imagery in conjunction with limited ground validation. This preliminary stratification was progressively refined by ocular reconnaissance in the original study area as well as the BPSA extension. Eight major and relatively discrete vegetation associations in addition to "old" and "new" agriculture were thus identified within the total study area. Representative areas within each of these strata were sampled for prey species.

Lagomorphs

Black-tailed Jackrabbits. Jackrabbits were censused using two different methods. Sixty 1.6-km transects previously established by Bureau of Land Management personnel (Figure 2) were walked in spring and fall from 1975 through spring 1978. Before this study was initiated, these transects were walked by BLM personnel in 1972, 1973, and 1974. In June 1976, 20 additional transects were walked in areas identified by Study III as intensively hunted by golden eagles. Gates (Gates et al. 1968) transect indices were converted to density estimates (no. rabbits/

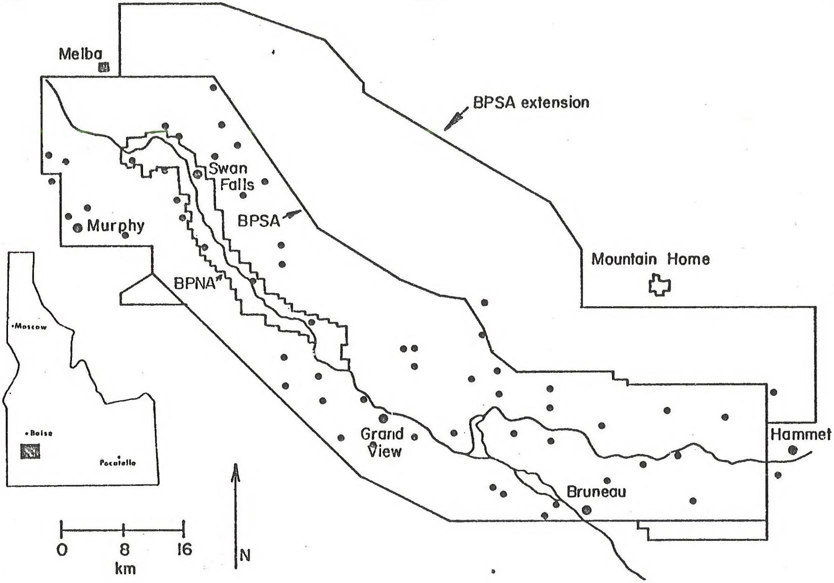

Figure 2. Location of BLM jackrabbit walking transects in the BPSA, Idaho.

km^2) by multiplying by 1.43, the conversion factor applied in similar vegetation types in northern Utah by Gross et al. (1974).

In 1975, jackrabbits were live-trapped in an attempt to assess the possible concentrating effect of sugar beet fields on jackrabbit distribution. Folding live-traps (38 x 38 x 102 cm) were arranged in a 4 x 4 grid on the north side of Victory Lane road in big sagebrush. A large beet field was situated on the south side of the road. Rabbits were ear-tagged and released at each capture site.

During 1977 and 1978, jackrabbits were censused using a "modified area-estimate method" (Flinders and Hansen 1973). Four transect routes, averaging 22 km in length, were established in the study area to census the more common vegetation types (Figure 3). One transect of 1977 was altered in 1978 in order to census a different vegetation type. Each transect was censused with a hand-held spotlight (100 watt, 12 volt, 200,000 candlepower) on three different nights from mid-May through mid-June in a randomized block sampling design. The census vehicle was driven 10-16 km/hr, and both sides of the transect line were observed. Effective sighting distance was established as 50 m on a side, creating a 100 m-wide transect. In each vegetation type sampled, a density correction factor (Emlen 1971) was derived to obtain absolute density estimates. This correction factor accounted for sighting variability due to composition and structural differences among vegetation types.

Jackrabbit walking transects were sorted by vegetation type, and data were pooled over five years of collection (1974-1978) in spring and fall. These results were tested with results from the spring 1978 area-estimate method to determine whether there was any method correlation.

In May-June of 1977 and 1978, 50 and 49 jackrabbits, respectively, were collected at night. Eye lenses were removed and preserved in 10

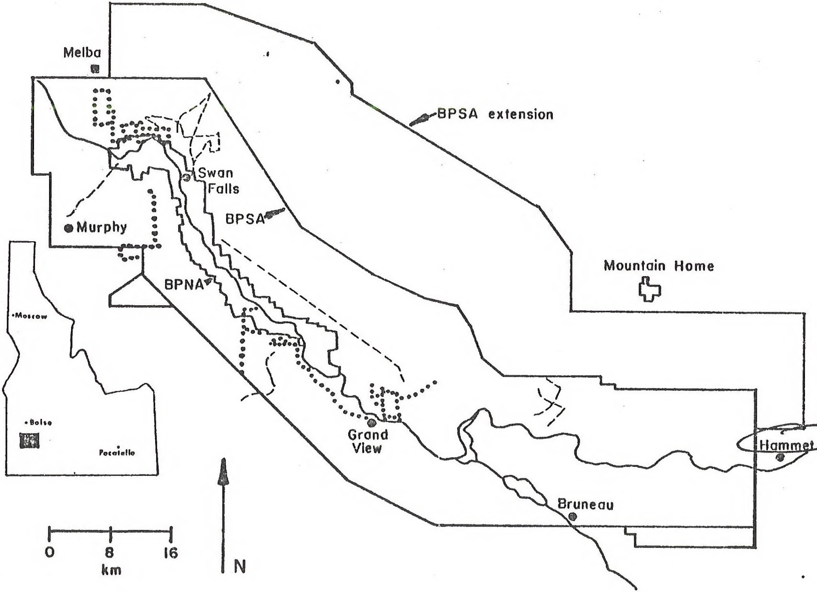

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Figure 3. Location of jackrabbit driving transects (dashed line) and pheasant crow-count transects (dotted line) in the BPSA, Idaho.

percent formalin. The lenses were dried and weighed, and lens weights were converted to age classes based on the criteria of Tiemeier and Plenert (1964).

Cottontails. Cottontails were censused using capture-recapture trap lines. Lines of 8-12 folding live-traps were placed in selected vegetation sites throughout the study area for a period of 10-12 days. In the first year of trapping, homemade traps were used, allowing only four different areas to be trapped in spring, summer, and fall; and in each succeeding year, approximately 35 sites were trapped, with three specific areas trapped each season (Figure 4). Some sites were selected to test population variability between golden eagle hunting areas and nonhunting areas. Trapping success did not allow useful population density estimates to be calculated, but an index of number captured/100 trap nights was obtained for comparison among sites.

Throughout the study, three areas were trapped each spring, summer, and fall to detect any intra-annual or annual changes in rabbit densities. These three areas were canyon riparian, canyon talus, and canyon rim. The canyon riparian site was adjacent to the Snake River in heavy vegetation composed of willows, shrubs, and lush grasses. The canyon talus site was on a slope with low density vegetation composed of greasewood, big sagebrush, and scattered grasses interspersed in jumbled, large-boulder fields. The canyon rim site was at the edge of the canyon rim, with bare, exposed lava near the edge; native vegetation occurred back from the edge of the rim.

To supplement information on distribution and habitat preference, an area of 375 km^2, composed mainly of disturbed agricultural lands, was surveyed extensively for cottontails (Figure 5). Transect lines were walked

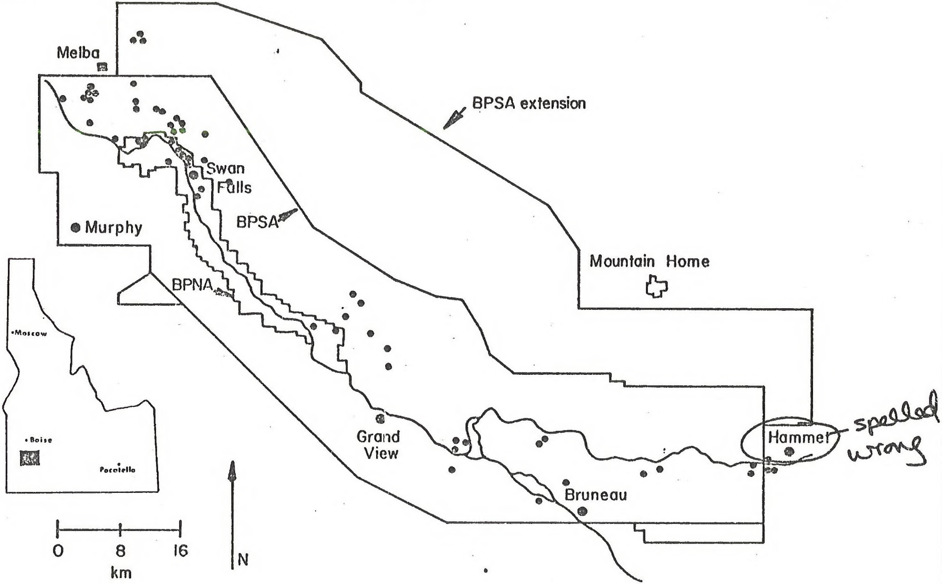

Figure 4. Location of cottontail live-trap sites in the BPSA, Idaho.

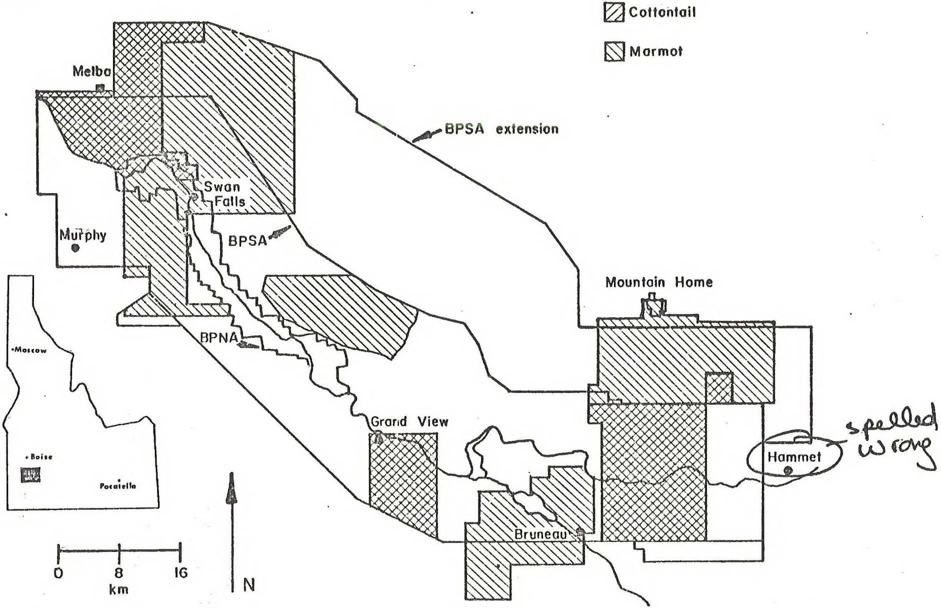

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Figure 5. Location of marmot and cottontail survey areas in the BPSA, Idaho.

periodically in each 3 km^2 block, and local residents were interviewed to assist in locating cottontail populations. Vegetation, land use, and other topographic features were noted at all areas surveyed regardless of whether cottontails were present.

Rodents

Marmots. From February through March of 1976 and 1977, marmots were live-trapped within a 0.1-ha rocky cliff outcrop at the Evans ranch near Melba, Idaho. Marmot colony distribution in the canyon was mapped by walking a section of the canyon along the river reach from Swan Falls Dam to the Evans ranch. In 1978, additional areas near the Evans ranch and other areas in and near the Birds of Prey Natural Area were trapped for marmots (Figure 6). Marmots were also captured at cottontail trap sites. These were considered incidental captures which aided primarily in determination of the distribution of marmot colonies.

During 1978, an intensive effort was made to determine qualitatively the preferred habitat of marmots and to determine the distribution in areas of agriculture and native vegetation. Approximately 1300 km^2 of land within the study area was surveyed both visually and by interviewing local residents (Figure 5). Marmot colonies were located on 7.5-minute maps, and notes were made as to probable size of colony, land use, and any geographic features which may influence marmot colonization. Areas which did not contain marmot colonies were also described in detail.

Wood Rats. Bushy-tailed wood rats and desert wood rats were subjected to the same trapping regime, schedule, and sites as cottontail rabbits. Location of trap sites is shown in Figure 4.

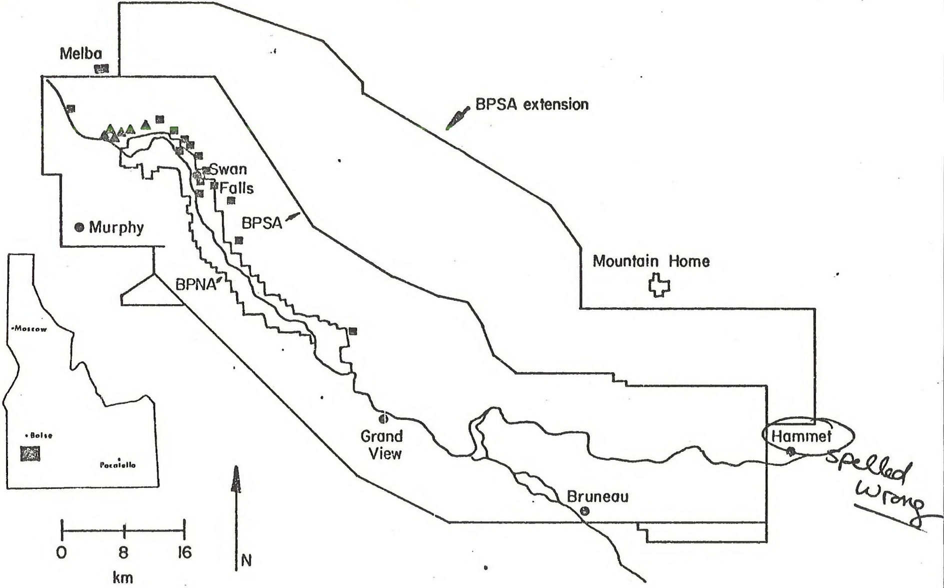

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Figure 6. Location of marmot live-trap sites (triangles) and small-rodent snap-trap sites (squares) in the BPSA, Idaho.

Small Rodents. Small rodents were censused using live-trap grids in eight representative vegetation types in 1975 (cf. Montan 1977). Live-trap grids consisted of a 10 x 10 arrangement of Sherman traps spaced at 15-m intervals. Traps were baited with a mixture of peanut butter and rolled oats and were operated for five-night periods in spring, summer, and fall. Animals were marked by toe-clipping.

Concurrent with live-trapping, snap-trap lines of 50 traps spaced at 15-m intervals and baited with peanut butter and rolled oats were operated near the live-trap grids.

In 1976, relative rodent indices of abundance were obtained at 34 sites by use of snap-trap lines of 25 traps for a two-night period. The snap-trap index used for a particular species and site was:

$$\frac{(\text{captures})\ (100)}{(\text{trap nights}) - (\text{sprung and missing traps}}$$

All sites were trapped in spring, summer, and fall.

In 1977 and 1978, small rodents were snap-trapped at 14 sites during July (Figure 6). Sites were selected to represent major vegetation types and land disturbances in the area. Number of captures per 100 trap nights was obtained for comparison among sites and species.

A complete description of the intensive small-rodent research done in 1975 and 1976 is presented in Appendix C. Information collected in 1977 and 1978 at the 14 snap-trap sites and data collected in similar habitat during the first two years of study allowed comparison of snap-trap indices among years, vegetation, and rodent species.

Gallinaceous Birds

Pheasants. Two indices of pheasant abundance, number of pheasants seen/km and number of calls/station, were obtained by the crow-count method (Kimball 1949) during the last half of April and the first part of May.

In 1975, only number seen/km was obtained. Routes were selected in 1975 (Figure 3) in an attempt to determine possible differences in pheasant abundance in areas of old and new agricultural practices. Four routes were located in old agriculture, three in new agriculture, and one in a new agriculture area with a large riparian strip through its center (referred to hereafter as the new agriculture-riparian area).

Chukar Partridges. The chukar partridge presented a censusing problem. In 1975, a census was attempted during May and late June, when chukar came to water in the Snake River Canyon. Two personnel walked the canyon, counting birds as they flushed or ran across open areas. In 1976 and 1977, an attempt was made to employ the rally-call method (Oeklaus 1976) during August. This resulted in the location of a few flocks in specific areas, but no estimates of densities were obtained. Field work demonstrated that this method did not warrant another season of use since responses were highly variable. Other studies have shown that it is impossible to census chukar accurately through the use of call counts (Oeklaus 1976, Christensen 1970).

Passerines and Pigeons

Passerines were censused by walking Emlen (Emlen 1971) transects in spring of 1975-1978, fall 1975, and summer 1978. Birds were grouped into horned larks, meadowlarks *(Sturnella neglecta)*, "sparrows" (family *Fringillidae)*, "blackbirds" (families *Icteridae* and *Sturnidae)*, and "others." "Other" species included ravens *(Corvus corax)*, mourning doves *(Zenaida macroura)*, rock pigeons *(Columba livia)*, swallows (family *Hirundinidae)*, kingbirds *(Tyrannus verticalis* and *Tyrannus tyrannus)*, quail *(Lophortyx californicus)*, robins *(Turdus migratorius)*, gulls (family *Laridae)*, and great blue herons *(Ardea herodias)*.

In 1975, one transect 450 m long was walked in each of six different vegetation types. These areas corresponded with the small-mammal live-trap grids (see Appendix C for grid locations). In 1976, a series of 18 sites, including the eight small-mammal live-trapping grids, were sampled between 16 May and 16 June. In 1977, ten different vegetation types were sampled between 15 April and 25 May (Figure 7). Some of these types were replicated. Transects were 1.6 km long in 1976 and 1977. In 1978, an intensified effort was made to collect density information in the ten "vegetation types." Eight transects were selected in each vegetation type throughout the study area (Figure 8). Each transect, 2 km long, was walked in early morning, once in April-May and once again in June-July. Bird densities in each vegetation type were then calculated for each two-month sample period (Emlen 1971).

From 16 to 18 August 1977, a visual census of pigeons *(Columbia livia)* was conducted. The north cliff of the Snake River Canyon beginning 2 km downstream of Swan Falls Dam and ending at the Halverson Lakes area was censused. Total transect length was 6.8 km. Along this portion of the Snake River, the cliff rises vertically 80-120 m.

A transect along the base of the cliff was selected and driven one hour after sunrise. Every 0.4 km a firearm was discharged, causing pigeon flocks to fly off the cliff face. A visual estimate was made of the flock size, and photographs were taken to determine the accuracy of visual estimates.

Statistical Analysis

In most circumstances, data were subjected to an analysis of variance to test for differences among means. An alpha level of 0.05 was considered statistically significant throughout the analysis. If the analysis of

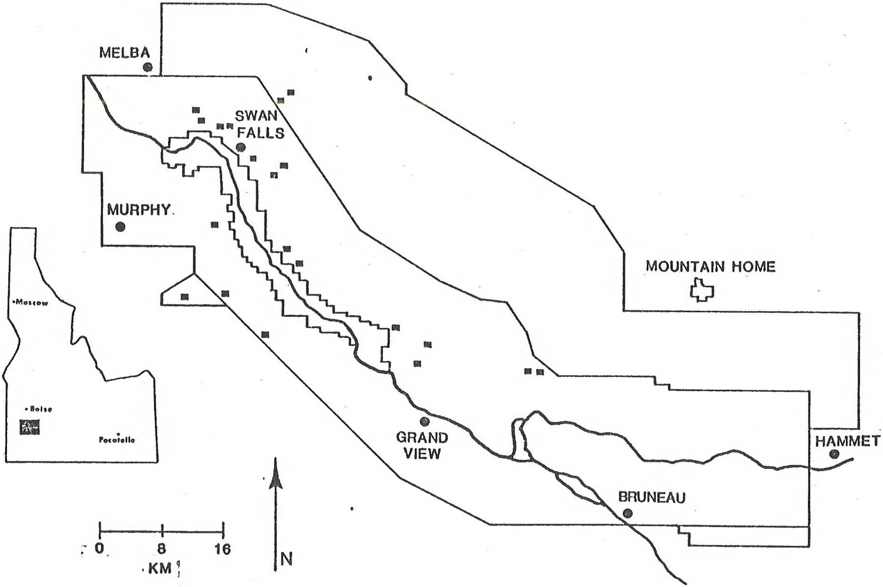


Figure 7. Location of passerine transects in the BPSA, Idaho (1977).

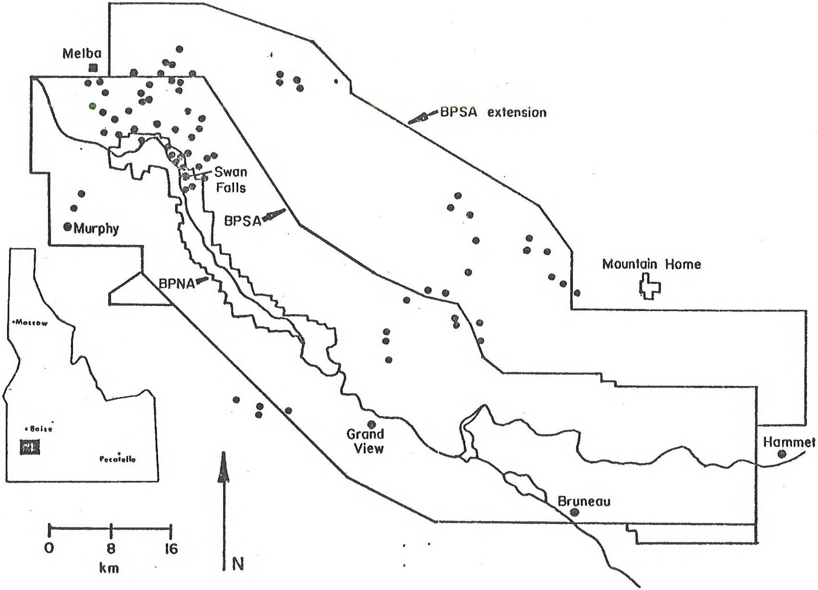


Figure 8. Location of passerine transects in the BPSA, Idaho (1978).

variance was significant, multiple range tests (Ott 1977, Hicks 1973, Snedecor and Cochran 1967, Tukey 1949) and linear contrasts (Hicks 1973, Nie et al. 1970) were performed to find which populations were statistically different. "T-tests" were also performed to test two population means. "Statistical package for the Social Sciences" (Nie et al. 1970) was used throughout the analysis.

RESULTS AND DISCUSSION

Vegetation Types

Division of the area into vegetation types during 1975 and 1977, which was used as a basis for sampling most prey species, resulted in ten different types (Figure 9), including "old" agriculture and "new" agriculture types. Sample sites were selected in homogeneous stands of the dominant plant species identified in each vegetation type.

"Old" agriculture areas were defined as areas which had older farms with fence-row vegetation present, gravity irrigation ditches and associated cover, and small fields with considerable edge present. "New" agriculture areas were defined as modern, "clean" farming areas with single fields typically covering 200 ha or more, with little or no vegetation cover present along fence rows, and irrigation typically accomplished by means of overhead sprinkler systems. It is well to note that many of the "old" agriculture areas are rapidly becoming ecologically similar to "new" agriculture due to burning practices employed on the "old" agriculture farms. Ditches and fence rows are burned periodically of all heavy cover, resulting in little or no cover.

In order to relate the vegetation types established for prey censusing in this portion of the study to the more quantitative 1978 vegetation map (Appendix B), a simple table was created (Table 1). Actual prey sampling was rarely done at sites which had vegetation composition at the extreme limits of composition noted in this table. Therefore, extrapolation of results in this portion of the study to areas of extremely high- or low-density vegetation within a vegetation type may be inappropriate. More knowledge of the functional response of prey to changes in vegetation composition and density is needed. This type of detailed study was clearly beyond the scope of this broad research program.

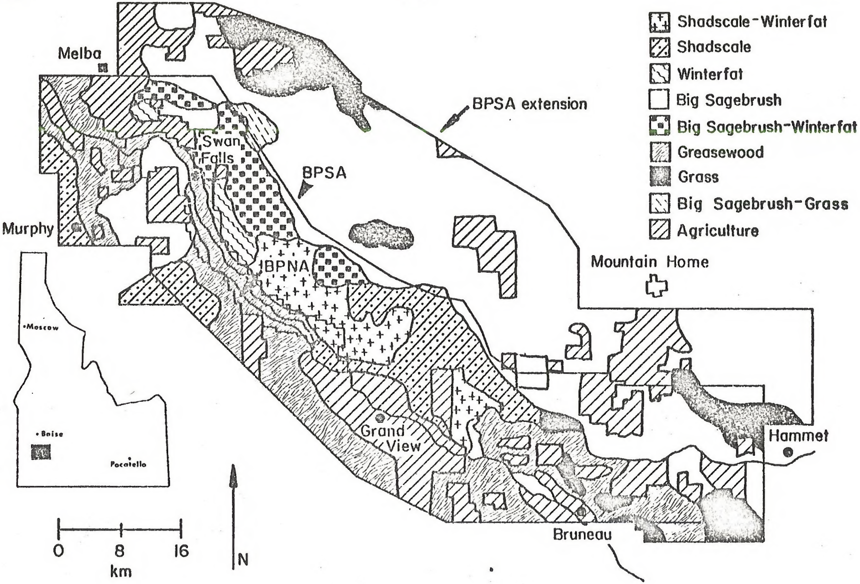


Figure 9. Major vegetation associations of the Snake River BPSA, Idaho.

Table 1. Description of vegetation types selected by this study for prey-base censusing in the Birds of Prey Study Area. "Old" agriculture and "New" agriculture are described in the text.

	Per Cent Composition					
Vegetation Type	Big Sagebrush	Winterfat	Grasses	Shadscale	Greasewood	Description
Big Sagebrush	> 1	< 1	≥ 0	< 1	< 1	-
Big Sagebrush-Winterfat	> 1	> 1	≥ 0	< 1	< 1	Patchy
Big Sagebrush-Grass	> 1	< 1	≥ 1	< 1	< 1	Patchy
Winterfat	< 1	> 1	≥ 0	< 1	< 1	-
Shadscale	< 1	< 1	≥ 0	> 1	< 1	-
Shadscale-Winterfat	< 1	> 1	≥ 0	> 1	< 1	Patchy or mixed
Grass	< 1	< 1	≥ 1	< 1	< 1	-
Greasewood	< 1	< 1	≥ 0	< 1	> 1	-

Lagomorphs

Black-tailed Jackrabbits. The population indices computed from the results of walking transects constitute the only relatively long-term data series pertaining to jackrabbit population levels on the BPNA. The indices obtained by this method for the period 1972-1978 are given in Table 2. These results may be compared to estimated mean jackrabbit densities in the more common vegetation types, obtained by the area-estimate method in 1977 and 1978, and presented in Table 3.

Population indices obtained from the walking transects indicate an increasing jackrabbit population over the last two years. These indices, which represent a single composite density estimate for the entire study area consisting of several vegetation types, are much higher than the estimates obtained by the area-estimate method. In theory, the walking transect index should have been lower in spring 1976 than in fall 1975, and higher in fall 1976 than in spring 1976. The fact that this was not true reflects a flaw in the method itself. One problem is that not all of the transects are in good jackrabbit habitat; therefore, during years of low jackrabbit numbers, the effective sampling ability of the transects is so low that the transects fail to document population changes. Secondly, the same conversion factor is being applied to all vegetation types censused although it was established for a single vegetation type--sagebrush *(Artemisia spp.)* in northern Utah.

The area-estimate method is also subject to potential sighting variability problems due to changes in jackrabbit activity caused by moon phase change and weather conditions. In this census, these effects were minimized and quantified using a randomized block sampling design.

Analysis of the results obtained by the area-estimate method revealed statistically significant differences in jackrabbit densities between 1977

Table 2. Jackrabbit population indices obtained during BLM jackrabbit transect sampling, Snake River BPSA, 1972-1978.

Year	Season	Number of transects	Number jackrabbits observed	Mean index	(N)	Jackrabbits/km^2
1972	Fall	26	9	43.8		62.6
1973	Fall	36	6	19.0		27.2
1974	Spring	34	4	12.3		17.6
1974	Fall	59	12	31.2		44.6
1975	Spring	60	7	12.5		17.9
1975	Fall	60	11	19.4		27.7
1976	Spring	61	21	57.7		82.5
1976	Fall	61	18	34.0		48.6
1977	Spring	59	24	30.6		43.9
1977	Fall	60	22	40.5		57.9
1978	Spring	57	13	41.7		59.7

Table 3. Jackrabbit density estimates, obtained by the area-estimate method on the Snake River BPSA, May 1977 and 1978.

Vegetation type		Mean jackrabbit density (No./km2) 1977	1978
Transect 1			
Big sagebrush (N.W.)		26.1	42.4
Big sagebrush - Winterfat		7.9	14.9
Big sagebrush - Grass		30.7	11.8
	Mean:	21.6	23.0
Transect 2			
Big sagebrush (N.W.)		37.6	36.8
Big sagebrush - Winterfat		11.4	18.4
Big sagebrush - Grass		41.3	24.3
	Mean:	30.1	26.5
Transect 3			
Shadscale		25.9	5.3
Shadscale - Winterfat		43.1	4.8
	Mean:	34.5	5.1
Transect 4			
Dense greasewood		0.0	---
Transect 5			
Big sagebrush (S.E.)		---	11.5

and 1978 within respective vegetation types. Of four vegetation types that could be tested, jackrabbit density increased in pure sagebrush ($t = 1.0$, d.f. = 10, $p<0.02$) and sagebrush-winterfat ($t = 2.99$, d.f. = 10, $p<0.02$). Densities decreased in sagebrush-grass ($t = 6.36$, d.f. = 10, $p<0.01$) and in shadscale ($t = 2.23$, d.f. = 10, $p<0.01$).

No significant differences among vegetation types within respective years were detected by application of Duncan's range test (Ott 1977) to the data. However, the 1978 jackrabbit densities in big sagebrush at the northwest end of the study area were significantly higher than those in the same vegetation type at the southeast end. Given the short length of the southeast transect and the fact that it was monitored only in 1978, this finding should be tested again.

A factor that may have influenced the differential jackrabbit distribution observed between years was a marked vegetation change from 1977 to 1978. Because of the prevailing drought conditions, vegetation was very sparse in 1977, with little or no undergrowth. In 1978, vegetation was very dense, and there was a significant increase of mustard plant throughout the area.

Observations in 1977 suggested that jackrabbits were more abundant in greasewood stands with an open understory than in those with a dense understory. A similar selection may have occurred in shadscale and other areas in 1978.

The results of other studies (Taylor and Lay 1944, Lechleitner 1958, Westoby and Wagner 1973) indicate that black-tailed jackrabbits favor habitats which provide an interspersion of tall cover with open spaces. Jackrabbits may have maximum and minimum levels of tolerance to height and density of vegetation. Results in this study support this idea.

In Utah, Currie and Goodwin (1966) found that grasses, forbs, and shrubs were grazed by jackrabbits in early spring. Grasses were preferred in late spring and summer, and shrubs were preferred throughout late fall and winter. This may imply movement of jackrabbits to different areas throughout the year depending upon season and/or vegetation condition. Seasonal movements of jackrabbits have been observed elsewhere (French et al. 1965). Jackrabbit movements may affect eagle hunting patterns throughout the year because of shifts in rabbit concentrations and vulnerability.

In June 1976, 20 jackrabbit transects were walked in areas identified by Study III as being intensively hunted by golden eagles. The mean density for these areas (Table 4) was significantly lower (t = 4.46) than the mean density estimated for the entire study area from the results of the BLM transects in the same spring. Conceivably, golden eagles respond to vulnerability rather than densities alone. Areas with low cover (e.g., short grasses and winterfat), in which the animals are probably more vulnerable, also harbor low jackrabbit densities. By contrast, big sagebrush and moderate-density greasewood have relatively higher jackrabbit densities, but vulnerability to avian predators is probably lower.

Mean jackrabbit density indices for the five-year period 1974-1978, pooled according to the vegetation type in which the respective transects were located, are given in Table 5.

Lens weight data were obtained from jackrabbits collected in June of 1977 and in April through May of 1978. This separation of collection dates was reflected in an apparent difference in the observed age structure of the rabbits collected. In 1977, of 50 rabbits collected, 66 percent were young-of-the-year (Age Class I, Tiemeier and Plenert 1964), comparent to 6 percent of 49 rabbits collected in 1978. The majority

Table 4. Jackrabbit walking transects in eagle hunting areas. Snake River Birds of Prey Natural Area, Idaho 29 May - 14 June, 1976.

Grid Location	Description	No. transects	No. jackrabbits	(N)	Density (1.43 N) (jackrabbits/km^2)
(45.0,77.0)	Section 9 Pole 60, Big Baja	5	0	0	-
(48.9,75.0)	Section 24 Pole 33, Big Baja	5	1	12.5	17.5
(Area from 30.5,92.7 to 30.8,92.3 to 31.9,93.0 to 31.5,93.5)	Near pole 241	5	2	5.4	7.7
(48.0,77.0)	Section 12 Dorsey Butte	5	0	0	-
Totals and Means for hunting areas		20	4	4.5	6.4
Study area transects:					
Spring, 1976	Entire Study area	61	21	57.7	82.5
Fall, 1976	Entire Study area	61	18	34.0	48.6

Table 5. Mean indices of jackrabbit density based on five years (1974-1978) of walking transect data, pooled by vegetative type.

Vegetation	Density (no./km^2)
Shadscale - Winterfat	5.6
Shadscale	66.2
Greasewood	49.0
Big sagebrush	49.0
Big sagebrush - Winterfat	21.3
Big sagebrush - Grass	56.5
Grass	0.6
Winterfat	0.0

(94 percent) of the rabbits collected in 1978 were yearling (Age Class II), whereas 32 percent were yearlings in 1977. One adult of 2 years or more (Age Class III) was collected in 1977 and none was collected in 1978. The overall sex ratio was similar between years, with 1.1 males:1.0 females in 1977 and 1.0 males:1.0 females in 1978. Thirty percent of the adults in 1977 had embryos past half term ($\bar{x} = 2.3$), whereas 35 percent were past half term ($\bar{x} = 4.1$), with 48 percent pregnant but not past half term ($\bar{x} = 5.4$) in 1978. No juvenile females were pregnant in 1978.

Cottontail Rabbits. Three live-trap sites were trapped every spring, summer, and fall throughout the study in an attempt to detect possible intra- and inter-annual changes in rabbit densities (Table 6). Although an analysis of variance yielded a significant F value ($F = 2.49$, d.f. = 10/20, $p = 0.05$), no differences among seasons could be detected by means of multiple comparison techniques. However, the indices appeared to be higher in spring and summer than in fall. Among vegetation types, there were significantly higher ($F = 19.01$, d.f. = 2/20, $p < 0.01$) indices of abundance in canyon talus and canyon riparian than at the canyon rim site. Canyon rim sites normally had higher indices than anywhere else in the desert, so it is safe to say that the riparian and talus areas support most of the cottontail population in the desert area.

Indices of abundance obtained from cottontail live-trapping efforts in 1977 showed no significant differences ($t = 1.07$, d.f. = 4, $p > 0.05$) between areas identified by Study III personnel as eagle hunting areas and areas of comparable terrain and vegetation that were not intensively hunted by eagles. The areas trapped were located in shadscale and canyon talus.

The results from other sites trapped throughout the study area (Tables 7 and 8) show that cottontails inhabit primarily areas with rocky

Table 6. Cottontail live-trapping results in the Snake River BPSA for three sites which were sampled three times annually, 1975-1978.

Site	Season	No. captures/100 trap nights			
		1975	1976	1977	1978
Canyon talus	Spring	14.4	10.0	4.6	6.0
	Summer	11.1	11.0	12.1	5.0
	Fall	8.3	5.2	12.5	---
Canyon riparian	Spring	10.0	10.7	8.3	6.0
	Summer	8.3	9.0	14.0	3.0
	Fall	6.1	10.5	11.4	---
Canyon rim	Spring	0.0	1.9	3.0	0.0
	Summer	6.9	8.0	6.7	3.0
	Fall	2.8	1.9	1.1	---

Table 7. Cottontail, marmot, and bushy-tailed wood rat live-trapping results in the BPSA, 1977.

Location	Description	Month of Trapping	No. Caught/100 Trap Nights			
			S.n.	N.c.	M.f.	Other
(89.60,32.40)	Sagebrush-Winterfat	Feb.	-	-	-	-
(92.80,24.30)	Rock Cliff/Farm	Feb.	-	19.0	8.7	-
(88.70,34.05)	Sagebrush-Winterfat/Farm	Feb.	-	-	-	-
(93.45,29.15)	Sagebrush	Feb.	0.9	-	-	3.7 L.c.
(93.05,29.40)	Sagebrush/Farm	Feb.	4.2	-	-	2.1 L.c.
(89.55,30.95)	Canyon Rim (1)	Mar.	3.0	2.0	1.0	-
(87.25,32.10)	Canyon Talus	Mar.	4.6	-	6.4	-
(91.00,30.25)	Canyon Riparian	Mar.	8.3	8.3	-	-
(94.75,26.30)	Grass	Mar.	-	-	-	-
(95.35,26.40)	Grass/Farm	Mar.	-	-	-	-
(94.60,28.20)	Winterfat	Mar.	-	-	-	-
(94.60,28.02)	Winterfat/Farm	Mar.	-	-	-	-
(92.40,32.55)	Trio Butte (Rocky Hill)	Mar.	3.1	2.3	-	2.3 L.c.
(77.50,43.70)	Shadscale	Mar.	-	-	-	-
(76.90,44.70)	Shadscale-Winterfat	May	-	-	-	0.5 L.c.
(75.50,46.55)	Canyon Rim (2)	May	8.3	1.2	-	1.2 L.c.
(74.80,34.50)	Greasewood	May	-	-	-	0.6 L.c.
(95.60,20.40)	Greasewood/Farm	May	1.9	-	-	-
(90.60,29.50)	Canyon Rim (4)	June	3.3	1.7	-	-
(89.55,30.95)	Canyon Rim (1)	June	6.7	1.7	-	-
(87.30,32.40)	Canyon Rim (5)	June	3.3	1.7	-	0.8 S.p.
(87.25,32.10)	Canyon Talus	June	12.1	-	3.0	-
(91.00,30.25)	Canyon Riparian	June	14.0	4.0	2.0	1.0 E.d.
(93.40,29.05)	Rocky Hill-Sagebrush	July	2.0	-	-	4.0 L.c.
(94.50,29.35)	Rocky Hill-Sagebrush	July	4.0	1.0	-	-
(94.35,29.60)	Rocky Hill-Sagebrush	July	3.0	-	-	2.0 L.c.
(91.00,30.50)	Sagebrush (Sandy)/Farm	July	-	-	-	-
(91.80,26.80)	Canyon Rim (H.L.)	July	2.0	10.0	-	-
(80.10,42.80)	Rocky Hill-Shadscale	July	3.0	-	-	1.0 L.c.
(79.85,43.10)	Rocky Hill-Shadscale	July	3.0	-	-	5.0 L.c.
(78.20,42.60)	Rocky Hill-Shadscale	July	2.0	-	-	4.0 L.c.
(77.50,42.00)	Dry Creek Bed - Rocky	July	3.0	-	-	2.0 L.c.
(77.50,41.25)	Canyon Rim (Desolate)	July	-	4.0	-	2.0 L.c.
(67.00,74.50)	Hilly Talus	Aug.	2.0	6.0	-	-
(66.95,74.50)	Canyon Rim (I.C.)	Aug.	13.0	7.0	-	1.0 E.d. 1.0 M.m.
(66.40,75.50)	Talus (1)	Aug.	7.0	5.0	-	-
(66.70,75.20)	Talus (2)	Aug.	7.0	2.0	-	-
(67.05,75.25)	Talus (3)	Aug.	7.0	5.0	-	-
(89.55,30.95)	Canyon Rim (1)	Dec.	1.1	3.4	-	4.0 N.l.
(91.00,30.25)	Canyon Rim	Dec.	11.4	6.8	-	-
(87.25,32.10)	Canyon Talus	Dec.	12.5	-	-	-

E.d. - *Erithizon dorsatum*

L.c. - *Lepus californicus*

M.f. - *Marmota flaviventris*

M.m. - *Mephitis mephitis*

N.c. - *Neotoma cinerea*

N.l. - *Neotoma lepida*

S.n. - *Silvilagus nuttalli*

Table. 8. Cottontail, marmot, and bushy-tailed wood rat live-trapping results in the BPSA, 1978.

Location	Description	Month of Trapping	No. caught/100 trap nights			
			S.n.	N.c.	M.f.	Other
(92.8,24.1)	N.W. Rocky cliff	Mar.	-	3.8	3.1	-
(92.8,24.2)	N.E. Rocky cliff	Mar.	6.2	4.6	2.3	-
(92.6,24.1)	S. Rocky cliff	Mar.	-	-	1.5	-
(90.9,90.3)	Canyon Riparian	Mar.	6.0	5.0	-	-
(87.3,32.2)	Canyon Talus	Mar.	6.0	-	-	-
(92.7,24.4)	Bull Pen cliff	Mar.	-	5.4	5.8	-
(92.8,24.4)	N. Rocky area	Mar.	2.7	-	4.5	-
(95.6,22.8)	Weedy fenceline in Old Ag.	Mar.	-	-	-	-
(90.9,30.4)	Canyon Rim	Mar.	-	7.0	-	-
(95.8,22.6)	Weedy irrigation ditch	Mar.	-	-	-	-
(96.8,26.3)	Big Sagebrush/Farm	Apr.	-	-	-	-
(95.5,20.5)	Big Sagebrush-Budsage/ Farm irrigation ditch	Apr.	3.3	-	-	-
(96.2,22.8)	Weedy fenceline in Old Ag.	Apr.	-	-	-	-
(94.3,22.9)	Irrigation ditch	Apr.	-	-	-	-
(95.8,22.9)	Irrigation ditch (heavy cover)	Apr.	-	-	-	-
(95.8,22.4)	Irrigation ditch/Heavy greasewood/Farm	Apr.	5.4	-	-	-
(99.2,26.5)	Big sage	May	-	-	-	-
(99.6,26.5)	Rocky knoll/Big sagebrush	May	4.0	-	-	-
(99.2,26.1)	Big sagebrush/Farm	May	1.0	-	-	-
(92.8,26.6)	Canyon Rim	May	-	9.0	3.0	-
(92.2,26.9)	Talus top	May	1.0	3.0	1.0	-
(92.2,26.8)	Talus base	May	4.0	2.0	-	-
(64.5,57.6)	Riparian	May	1.0	-	-	-
(56.2,67.5)	Greasewood-big sagebrush/ New ag.	May	-	-	-	-
(66.2,66.4)	Greasewood	May	1.0	-	-	-
(67.9,58.5)	Rocky areas/Farm	May	-	-	-	-
(68.1,58.6)	Rocky area/Big sagebrush	May	-	-	-	-
(65.2,59.6)	Big sagebrush	May	-	-	-	-
(90.9,30.4)	Canyon Rim	June	3.0	5.0	-	-
(87.5,32.1)	Canyon Talus	June	5.0	2.0	2.0	-
(88.6,31.6)	Canyon Talus	June	1.0	5.0	5.0	-
(89.2,30.9)	Canyon Flats	June	5.0	-	3.0	-
(91.0,30.4)	Canyon Riparian	June	3.0	10.0	-	-
(66.1,50.5)	Irrigation ditch/Greasewood	July	4.0	-	-	-
(66.1,51.5)	Talus top	July	2.0	4.0	4.0	-
(68.4,52.1)	Canyon Rim	July	5.0	4.0	-	-
(67.6,51.2)	Riparian	July	1.0	10.0	-	-
(71.1,47.2)	Greasewood/Farm	July	5.0	-	-	-

M.f. - *Marmota flaviventris*

N.c. - *Neotoma cinerea*

S.n. - *Sylvilagus nuttalli*

outcrops or heavy vegetative cover that is present all year long. Trapping in old agricultural areas along fence rows, irrigation ditches, and roadside ditches revealed no cottontails present unless the cover was present throughout the year. Most cover along fence rows and irrigation ditches in areas of old agriculture presently is burned each year, thereby eliminating potentially good cottontail habitat.

An intensive survey covering 375 km^2 in primarily agricultural areas corroborates the above findings. Farm fence rows in old agriculture land did not harbor cottontails unless good permanent cover was nearby. This "cover" included old buildings, rock piles, abandoned farm machinery, etc. Areas of modern agricultural practice had low densities or no cottontails except near permanent cover.

In vegetation and topography similar to that found in the BPSA rangeland with the addition of western juniper *(Juniperus occidentalis)*, McKay and Verts (1978) found cottontail densities varying from 6.6 to 254.4/100 ha in monthly censuses. They indicated that drought had the greatest impact on younger cohorts, possibly as the result of a reduction in succulent forage.

Cottontails do not inhabit native vegetation in the desert unless a rocky outcrop or similar cover is present. In the canyon, the talus and riparian areas support excellent cottontail populations. Modern farming does not increase rabbit abundance at the margins of the fields except near permanent cover, and habitat within the agricultural area itself is eliminated. Areas of old agricultural practices have more cottontails than areas of new agricultural practices because the fields are much smaller. This effectively increases the ratio of perimeter to area and thus the probability of a field margin being located in close proximity to suitable cover.

Marmots. Intensive live-trapping of marmots was conducted in February of three consecutive years at the Evans ranch pond, an area with a low cliff and talus slope below the cliff. In 1976 a Schnabel (Overton 1969) estimate of density at this site was 15.9 marmots/ha, as compared to 13.5 marmots/ha in 1977. Only two marmots were captured in 1978. Later in 1978, numerous adult marmots were observed in this area. Possibly trap-shy animals may have accounted for the apparent low capture rate observed in 1978.

During the course of the study, other sites were trapped specifically for marmots; and some incidental marmot captures occurred during cottontail trapping (see Tables 7 and 8). One area, located 0.4 km southeast from the Evans ranch site yielded a Schnabel estimate of 10.5 animals/ha. Another area of cliff with talus immediately below it, approximately 6.0 km from the Evans ranch site, yielded an estimate of 10.0 marmots/ha. An effective trap distance of 25 m was used in the calculation of these density estimates. Schnabel estimates could not be calculated at other sites because of low capture frequencies.

The overall sex ratio of trapped animals was 1.0 males:0.8 females (n = 44). Weights varied from 900 to 2500 g for adult females ($\bar{x}$ = 2020, n = 17) and 1100 to 4150 g for adult males ($\bar{x}$ = 2525, n = 20). In early spring, no young-of-the-year were captured, but in late May and early June some immature marmots were caught which weighed from 700 to 1600 g ($\bar{x}$ = 920, n = 6). The sex ratio of the immature marmots was 1.0 males:0.5 females (n = 6).

An extensive survey of 1300 km^2, combined with trapping results, gave a good idea of marmot habitat requirements. No marmots were found unless suitable burrow sites and a source of succulent vegetation were present.

Open water also seemed to be important. No marmots were found in native desert vegetation due to lack of moisture. The canyon, with an open water source and rich vegetation, supported marmot colonies. Farming of any type will allow colonization if the farm edge is located near good marmot burrow sites and a source of rich vegetation and/or water is nearby. Burrow sites consisted primarily of talus slopes or other jumbled, rocky outcrop. Detailed location of all colonies located in the 1300 km^2 survey are in the Birds of Prey office on 7.5-minute maps.

Wood Rats. Bushy-tailed wood rats were trapped at three sites in spring, summer, and fall in 1975 through 1978 (Table 9). There was no statistical difference in number of animals captured/100 trap nights among years ($F = 0.54$, d.f. = 2/20, $p > 0.25$) or trap sites ($F = 0.46$, d.f. = 10/20, $p > 0.25$). Desert wood rats were captured along the canyon rim and observed in riparian vegetation in the canyon itself. Wood rats were also captured incidental to cottontail trapping (Tables 7 and 8). These captures indicate a habitat preference for rocky outcrops and talus slopes. In the desert, wood rats were not found unless suitable rocky cover was located nearby. Their habitat requirements parallel closely those of cottontails.

Small Rodents. Small-rodent snap-trap results pooled over four years are presented in Table 10. Deer mice were significantly more abundant than any other rodents during each year of snap-trapping in July ($p < 0.001$ in every year). The only other species which was locally abundant was the Ord's kangaroo rat. It was confined to areas of disturbed land such as roads or farm edge. No snap-trap index differences among vegetation types were detected for any rodent species except the deer mouse, which had significantly higher indices of abundance in canyon

Table 9. Bushy-tailed wood rat live-trapping results in the Snake River BPSA, 1975-1978.

		No. Captures/100 trap nights			
Vegetation	Season	1975	1976	1977	1978
Canyon Rim	Spring	8.6	0.0	2.0	7.0
	Summer	1.6	0.0	1.7	5.0
	Fall	0.0	1.0	3.4	---
Canyon Talus	Spring	2.9	2.0	0.0	0.0
	Summer	3.6	4.0	0.0	0.0
	Fall	6.3	0.0	0.0	---
Canyon Riparian	Spring	5.7	0.7	8.3	5.0
	Summer	1.6	0.0	4.0	10.0
	Fall	1.6	0.0	6.8	---

Table 10. Small rodent snap-trap results of July pooled over four years (1975-1978) in the Snake River BPSA, Idaho.

Vegetation	No. captures/100 trap nights						
	P.m.	P.p.	D.o.	O.l.	P.c.	E.m.	S.t.
Big Sagebrush	11.9	1.1	0.5	1.1	0.0	0.6	0.6
Big Sagebrush-Winterfat	20.8	1.6	0.8	1.5	0.0	0.0	1.6
Winterfat	7.1	0.5	0.5	2.4	0.0	0.0	0.8
Burn-grass	16.4	0.3	8.0	0.0	0.0	0.0	0.0
Grass	7.3	0.0	0.6	0.0	0.0	0.0	0.0
Big Sagebrush-Winterfat/ Farm	8.5	0.0	9.3	0.0	0.0	0.0	0.8
Winterfat/Farm	7.0	0.0	12.7	0.0	0.0	0.0	4.7
Riparian	31.5	0.0	0.0	0.0	0.3	0.0	0.0
Shadscale	11.7	0.0	0.0	1.4	0.0	0.0	0.0
Shadscale-Winterfat	11.0	1.2	3.7	1.0	0.0	0.0	1.0
Canyon Talus	40.9	3.5	0.0	0.0	2.7	0.0	0.0
Big Sagebrush/Farm	10.3	0.0	11.6	1.3	0.0	0.0	0.0
Canyon Rim	8.6	0.0	0.0	0.0	0.0	0.0	0.0
Greasewood	20.8	2.1	1.3	0.0	0.0	0.0	0.0

D.o. - *Dipodomys ordii*
E.m. - *Eutamias minimum*
O.l. - *Onychomys leucogastor*
P.c. - *Peromyscus crinitus*
P.m. - *Peromyscus maniculatus*
P.p. - *Porognathus parvus*
S.t. - *Spermophilus townsendi*

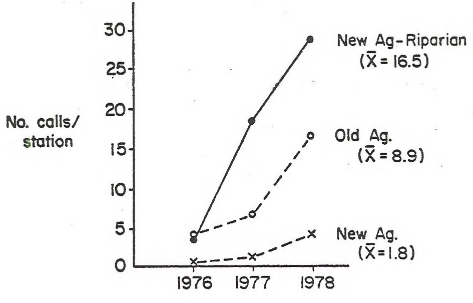
talus and canyon riparian areas (F = 2.98, d.f. = 13/44, p = 0.006). Disturbed sites near farms showed higher snap-trap indices for Ord's kangaroo rat than other sites. All other rodents showed low indices of abundance in all vegetation types.

Most of the species snap-trapped are nocturnal or crepuscular and thus probably supply little available prey for diurnal raptors. The only diurnal species, other than the Townsend ground squirrel, are the white-tailed antelope squirrel (*Ammospermophilus leucurus)* and the least chipmunk *(Eutamias minimus)*. Least chipmunks are few in number and are restricted to big sagebrush; thus, they are largely unavailable to raptors. White-tailed antelope squirrels were primarily restricted to the south side of the Snake River, where the populations are widely scattered. Some squirrels were sighted on the north side of the Snake River as the study progressed, indicating possible extension of their range.

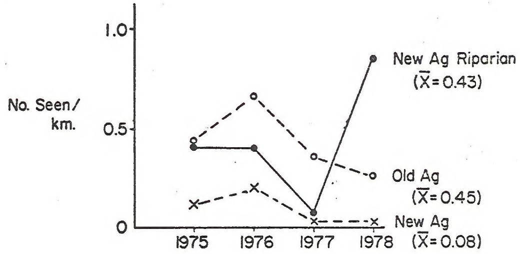
Other rodent species observed, but not systematically trapped, were pocket gophers *(Thomomys spp.)*, beavers *(Castor canadensis)*, and muskrats *(Ondatra zibethica)*. Pocket gophers occurred in irrigated fields, irrigation ditchbanks, alluvial soils of the canyon bottom and side streams, and certain north-facing slopes in Con Shea Basin and on Sinker Butte. Beaver and muskrat were restricted to aquatic and riparian habitats along the Snake River and associated streams and marshes.

Gallinaceous Birds

Pheasants. The mean values for the two indices of pheasant abundance over all years sampled are shown in Figure 10. The graph of number of calls per station demonstrates a constant increase in pheasant responses from 1976 through 1978, with higher pheasant responses in the



(Annual pooled means given after each ag practice)



(Annual pooled means given after each ag practice)

Figure 10. Results of pheasant crow-count transects in the BPSA, Idaho (1975-1978). (No. calls/station was not obtained in 1975.)

new agriculture-riparian type than in all other types for the three years of pooled data. The graph of number of pheasants seen per km does not exhibit this temporal trend but does demonstrate similar relationships among agriculture practices.

The results of statistical tests support these observations (Table 11). There was a significantly higher number of calls per station in new agriculture-riparian than in old agriculture, and significantly higher index in old agriculture than new agriculture. There was also a significantly higher number of calls per station from year to year within all agriculture practices except new agriculture. Tests of the number of birds seen per km showed no significant differences between new agriculture-riparian and old agriculture but indicated a significantly lower index in new agriculture than in the other two treatments.

The method employed may be subject to problems as the result of differences in the ability to hear pheasants in different vegetation types. However, the elimination of this bias would probably result in an even greater difference in indices of pheasant abundance among the areas studied. Pheasant calls should have been most easily heard in open, new agriculture, at areas which had the lowest number of calls per station, of all the areas inventoried. Variation in weather during census efforts was minimal, and any route censused during highly different weather conditions was repeated at the next opportunity. The calls per station index appear to provide a reasonably accurate index of pheasant abundance among these three areas. By contrast, the number seen per km driven appears to be a less reliable index. Monitoring of transects was begun before sunrise, when visibility was limited. Moreover, visibility varied between transects with differing vegetation densities.

Table 11. Linear combination F-values and significance for pheasant crow-count data on the Snake River Birds of Prey Study Area. Significance < 0.05 indicates significant differences between the treatments being compared.

Number of calls/station 1975-1978

Comparison	F-value (df=1/15)	Significance (p)
Old Agriculture x New Agriculture	32.9	0.001
Old Agriculture x New Agriculture-riparian	17.9	0.001
New Agriculture x New Agriculture-riparian	62.2	0.001
1976 x 1977	14.4	0.005
1977 x 1978	20.5	0.001

Number of pheasants seen/km 1975-1978

Comparison	F-value (df=1/15)	Significance (p)
Old Agriculture-New Agriculture	25.7	0.001
Old Agriculture-New Agriculture-riparian	0.02	0.75
New Agriculture-New Agriculture-riparian	10.8	0.01

Changes in pheasant abundance in dense vegetation from year to year may not be detectable because of the few pheasants seen during censusing.

Chukar Partridges. Results of efforts to census chukars were primarily qualitative. Chukars were found to be largely restricted to the main Snake River Canyon and its tributaries. Flocks were highly mobile and predominantly utilized talus and cliff areas along the creeks. Within a 7.5-km stretch of the Snake River with large talus areas, three chukar flocks were located. No flocks were located along 12.6 km of shadscale and winterfat in the desert. A census of Sinker Creek yielded two chukar flocks in 3.5 km, with one flock of ten chukars. Flocks found in the course of these census activities were pinpointed on 7.5-minute maps, which are on file in the Birds of Prey office.

Passerines and Pigeons

Density of each passerine group censused in 1975-1977 is presented in Tables 12-14. The procedure was not well organized; consequently, information for the first three years of study is scattered among different vegetation types, with varying numbers of replications and transects of differing lengths. The densities of each "passerine" group censused in late spring and summer of 1978 are presented in Table 15. During spring and summer, horned larks showed significantly higher population densities ($F = 19.9$, d.f. = 9/74, $p < 0.001$) in the grass type than in any other vegetation. Big sagebrush-winterfat, winterfat, shadscale, and "new" agriculture had high densities as well, but the observed differences were not statistically significant. Spring and summer horned lark populations showed a significant increase in winterfat ($t = 3.9$, d.f. = 8.3, $p = 0.005$), shadscale ($t = 3.5$, d.f. = 13.8, $p = 0.004$), and grass ($t = 2.7$, d.f. = 11.7, $p = 0.019$). The population density of meadowlarks

Table 12. Passerine density in the Snake River BPSA, 1975.

Site	Location	Season	Density (No./ha) Horned Lark	Meadow-lark	Brewers Sparrow (*Spizella breweri*)	Sage Sparrow (*Amphispiza belli*)
Winterfat	(T2S R1E Sec. 7)	Fall	4.4	0.0	0.0	2.2
Big Sagebrush	(T1S R1W Sec. 24)	Spring	1.0	1.0	1.0	1.0
		Fall	0.0	0.0	0.0	5.6
Cheatgrass	(T2S R1E Sec. 14)	Fall	2.2	0.4	2.2	0.0
Greasewood	(T2S R2W Sec. 14)	Fall	11.1	2.2	0.0	0.0
Big Sagebrush	(T2S R1W Sec. 35)	Fall	8.9	11.1	0.0	0.0
Shadscale-Low Sagebrush	(T4S R1W Sec. 1)	Fall	4.4	0.0	0.0	0.0

Table 13. Passerine density in the Snake River BPSA, 16 May - 16 June, 1976.

Site		Density (No./ha)		
		Horned lark	Meadowlark	"Sparrow"
Burn	(32.3,88.0)	7.0	0.5	0.0
Winterfat	(31.7,89.8)	7.0	0.0	0.0
Big Sagebrush	(30.3,93.3)	0.0	6.2	4.8
Cheatgrass	(35.4,88.1)	5.0	1.1	4.3
Shadscale	(36.0,83.2)	23.8	0.0	0.0
Greasewood	(23.5,87.2)	9.6	27.0	0.0
Big Sagebrush	(29.3,85.1)	16.0	25.0	23.7
Shadscale-low Sagebrush	(29.0,78.0)	17.4	0.0	18.6
Burn	(31.5,88.5)	5.1	0.5	0.0
Shadscale-spiny hopsage	(27.4,78.8)	21.4	0.0	6.7
Spiny hopsage	(25.0,89.5)	15.7	0.0	5.0
Big sagebrush-shadscale	(36.0,83.2)	13.1	14.9	8.3
Big sagebrush-farm	(26.7,84.1)	4.6	10.1	3.0
Wheat field	(27.5,84.0)	1.9	0.0	0.0
Shadscale-farm	(50.0,74.0)	15.7	3.4	0.0
Prairie falcon hunting area	(38.9,97.9)	17.9	1.0	0.0
Shadscale	(52.4,75.0)	20.6	0.0	5.0
Golden eagle hunting area	(49.2,58.2)	11.0	1.4	0.0

Table 14. Passerine density in the Snake River BPSA, 15 April - 25 May, 1977.

Vegetation	No. Transects	Density (No./km^2) Horned Lark	Meadow-lark	"Sparrow"	Other
Big Sagebrush-Winterfat	5	9.4	0.6	6.3	1.3
Winterfat	4	27.3	0.0	3.9	3.9
Greasewood	1	3.9	0.0	0.0	0.0
Big Sagebrush/Farm	2	0.0	2.0	42.9	2.6
Grass	2	31.3	3.9	0.0	0.0
Big Sagebrush/Grass	1	15.6	0.0	0.0	0.0
Shadscale	2	23.4	3.1	39.1	0.0
Greasewood-Big Sagebrush	1	54.7	0.0	0.0	0.0
Big Sagebrush	1	52.2	36.6	46.9	0.0
Shadscale/Winterfat	2	15.6	0.0	2.6	0.0

Table 15. Passerine densities in the Snake River BPSA derived from "Emlen" transects. Densities are given for an April-May (late Spring) census over a June-July (Summer) 1978 census for each vegetation type and bird species (blackbirds include starlings).

	Density (No./km2)				
Vegetation	Horned lark	Meadow-lark	"Sparrow"	"Blackbird"	Other
Big Sagebrush (N.W.)	34.4 43.8	75.0 118.8	*206.3 543.8	0.0 0.0	25.0 550.0
Big Sagebrush (S.E.)	50.0 118.8	62.9 56.3	157.1 *856.3	14.3 0.0	35.7 31.3
Winterfat	*87.5 381.3	4.2 2.1	35.9 40.6	0.0 0.0	37.5 300.0
Shadscale	*181.3 *312.5	5.2 1.0	54.2 68.7	0.0 0.0	18.8 0.0
Grass	*525.0 *868.2	45.8 1.0	31.3 9.2	0.0 0.0	43.8 38.8
Greasewood	13.9 104.2	29.2 50.0	*172.2 191.7	0.0 0.0	91.7 83.3
Riparian	0.0 0.0	9.4 14.3	318.7 64.3	*868.8 *1721.4	*918.7 *942.9
Big Sagebrush-Winterfat	*268.8 *369.6	15.0 19.3	*243.7 *403.3	0.0 0.0	50.0 56.3
"Old" Agriculture	7.5 0.0	31.3 56.3	1359.4 *3365.6	1381.3 528.1	993.8 1256.3
"New" Agriculture	144.4 135.3	29.2 77.9	175.0 435.6	50.0 0.0	*550.0 94.9

* This bird species has significantly higher densities in this vegetation type and season than the other bird species ($p < 0.05$). In cases where more than one species has an asterisk in the same vegetation type, these species densities are significantly higher than the others but do not differ from each other.

showed no significant differences among vegetation types. Their highest densities were in big sagebrush in spring and summer. Populations did not increase within any vegetation type from spring to summer. In spring and summer, sparrows showed significantly higher densities in "old" agriculture ($F = 34.5$, d.f. = 9/75, $p < 0.001$) than in all other vegetation types. Big sagebrush, riparian, and big sagebrush-winterfat also had high sparrow populations. Sparrow densities increased significantly from spring to summer in big sagebrush-NW ($t = 3.1$, d.f. = 10.5, $p = 0.010$), big sagebrush-SE ($t = 3.8$, d.f. = 7.6, $p = 0.005$), and "old" agriculture ($t = 4.2$, d.f. = 7.9, $p = 0.003$). Their densities decreased in the riparian sites ($t = 3.3$, d.f. = 7.9, $p = 0.10$). Blackbird densities were not significantly higher for any vegetation type in spring; but in summer, riparian sites showed significantly higher blackbird densities ($F = 4.7$, d.f. = 9/75, $p < 0.001$) than the other vegetation types. "Old" agriculture and "new" agriculture sites also had high densities. There was no detectable increase in blackbird densities from spring to summer within any vegetation type. In the "other" category there was no vegetation type with significantly higher densities. "Old" agriculture had the highest density of "other" birds, followed by the riparian area. One vegetation type, the shadscale site, showed a decrease in density from spring to summer ($t = 2.4$, d.f. = 7.0, $p = 0.048$). The estimated densities at other sites remained fairly constant while others increased considerably. However, the high variances involved masked possible statistically significant differences.

Horned larks were more abundant than all other passerines in winterfat, shadscale, and grass areas (Table 15). "Sparrows" were more abundant than other passerines in big sagebrush, greasewood, and "old" agriculture.

In the riparian area, "blackbirds" and "other" birds represented the predominant species. The densities of the various bird species were more or less comparable in the riparian and "old" agriculture types, although the "other" category differed in species composition. "New" agriculture areas were similar to big sagebrush with the exception of "other" species in spring.

A mean of 51.0 pigeons/km (± 9.5) of canyon cliff was calculated. The cliff censused was a south-facing vertical wall, rising 80-120 m from the canyon floor.

CONCLUSIONS

Effects of Agriculture

The results of this study indicate that conversion of native range to intensive agriculture--at least the type of conversion presently used on the lands adjacent to the middle reach of the Snake River--spells a loss of habitat for the major mammalian prey species. While the crop lands thus created may provide some--albeit seasonally limited--food for jackrabbits and cottontails, they effectively eliminate the necessary cover for these animals. Various studies (Taylor and Lay 1944, Lechleitner 1957, Currie and Goodwin 1966, Westoby and Wagner 1973) have demonstrated that lagomorphs are relatively broad-spectrum feeders and that the quantity and quality of vegetative cover often constitute the limiting factor among their habitat requirements. Westoby and Wagner (1973) found that 70 percent of the forage removal by jackrabbits in a crested wheatgrass *(Agropyron desertorum)* field occurred within 300 m of its edge. Similarly, in our study, jackrabbits were observed at night at the edges of alfalfa fields, adjacent to native range vegetation. Considering the size of the fields involved, however, the loss of cover by elimination of native vegetation for agriculture outweighs the largely ephemeral food source that the margins of most agricultural fields provide.

Rock piles, created as an artifact when the desert is cleared for agricultural production, may provide some cover for marmots, and, to a lesser degree, for cottontails. For marmots, however, this effect seems to be limited to cases in which the fields are planted to alfalfa. Considering that most new agricultural areas are sown to row crops, and

and that marmots represent a prey item of only intermediate importance, the largely incidental benefits thus derived do not compensate for the overall loss of jackrabbit habitat involved.

Contrary to opinion from some quarters, the loss of jackrabbit habitat as a consequence of agricultural development will not be compensated by increased pheasant numbers. Again, lack of suitable vegetative cover is the key factor involved. There exists a substantial body of evidence from the Midwest (Joselyn and Warnock 1964, Labisky 1969, Nomsen 1963, Erickson and Wiebe 1973) that links declines in pheasant abundance with the loss of vegetative cover (especially residual nesting cover and winter cover) due to modern agricultural trends. These trends include the "clean farming" practices described above, the conversion of lands from the production of tame hays, small grains, and other suitable nesting habitats to the production of cash crops and renewed agricultural utilization of land formerly in non-use under several land retirement programs. The differences in pheasant abundance observed between areas of old and new agricultural practices in this study support the findings of these other studies.

Management Implications and Directions

Grazing. The design of this study incorporated no deliberate attempt to evaluate the possible impact of grazing by domestic livestock on the major prey species. Moreover, since virtually all portions of the study area have been subjected to grazing by sheep and cattle in the past, very limited inferences can be made from the empirical evidence collected to date. However, the results of other studies may be applicable. Studies by Phillips (1936) and Larrison and Johnson (1973) have shown that heavy grazing tends to diminish numbers of western harvest

mice *(Reithrodontomys megalotis)* and Great Basin pocket mice and increase the number of deer mice. The low capture rates of the first two species mentioned, observed by Montan (Appendix C) in the initial two years of this study, may reflect the history of heavy grazing in the area. In southern Arizona, Reynolds (1958) found that grazing enhanced habitat for Merriam's kangaroo rats *(Dipodomys merriami)* by reducing the density of the perennial grass understory. Likewise, Linsdale (1946) and Howard (1953) found that heavy grazing was associated with increased numbers of ground squirrels in California. Johnson and Melquist (1975) noted similar effects on the Birds of Prey study area.

While these results are somewhat academic in nature, they point up the possibility of using controlled livestock grazing as a biological tool to manipulate vegetation, thereby enhancing the habitat for specific prey species. This possibility--particularly with respect to jackrabbits and ground squirrels--might be profitably explored in future management-oriented investigations.

Fire. While the role of fire was not studied specifically in these investigations, Montan observed that deer mice and Ord's kangaroo rats showed an affinity for recently burned areas. This may indicate the potential of prescribed burning as a measure to increase the densities of some rodent prey species. The concomitant loss of shrub cover and hence jackrabbit habitat, however, could well outweigh the potential benefit effects of such practices. The effects of fire on the prey base could be studied experimentally in future investigations.

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